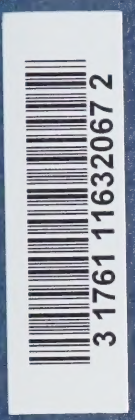

MORTALITY AMONG DIESEL SHOP AND MOBILE EQUIPMENT SERVICE CENTRE WORKERS STELCO STEEL, HAMILTON, ONTARIO

Gary M. Liss, MD, MS, FRCPC
Murray M. Finkelstein, PhD, MDCM
Health and Safety Studies Unit
Ontario Ministry of Labour

September 1993

H S HEALTH AND SAFETY STUDIES UNIT
S U ONTARIO MINISTRY OF LABOUR

SUMMARY

In December 1992, the Health and Safety Studies Unit of the Ministry of Labour (MOL) received a request for a formal investigation of the health experience among United Steelworkers of America (USWA) members employed by Stelco Steel in the Mobile Equipment Service Centre (MESC) and/ or Diesel Shop. The request was prompted in part by the results of a recently completed preliminary investigation by USWA Local 1005, which required many hours of dedicated information collecting, with the assistance of the Occupational Health Clinic for Ontario Workers. Concerns had been expressed about heart disease in particular; lung cancer was also mentioned. The main workplace exposure of concern was carbon monoxide (CO) which may be hazardous to individuals with preexisting heart disease. CO can precipitate angina or heart attack in individuals with coronary artery disease; it may also accelerate atherosclerosis.

At an initial meeting with the steering committee in February 1993, possible reasons for difficulty in the interpretation of the preliminary findings were discussed. The MOL agreed to carry out a formal analysis by obtaining the study list from the Clinic; obtaining missing dates of birth from the company; obtaining the cause of death information from the Registrar General of Ontario or Statistics Canada; and re-running the mortality analysis based on the 5-year eligibility criterion as had been used in the preliminary analysis. The company explored its records to determine if there were additional Diesel Shop/ MESC workers who should be included.

A total of 167 workers were included in the study group. The mortality experience of this group was compared to that expected in the general population of Ontario, after adjusting for age, and calendar period. The risk is estimated as the standardized mortality ratio (SMR) which is the Observed number of deaths divided by the Ontario average. The number of deaths from all causes was the same as that expected (observed 30, expected 30.2, SMR 99). Deaths from lung cancer were slightly increased (5 observed, 2.8 expected, SMR 179); 4 of these deaths occurred 20 or more years after first employment in the department. There were fewer deaths due to circulatory disease (heart disease and stroke) than expected (observed 12, expected 13.2, SMR 91). Ischemic heart disease (IHD) is the subgroup of circulatory disease which includes

coronary artery disease and heart attacks. All 12 circulatory deaths were due to IHD, which is just above that expected (SMR 121). Among those dying at age less than 65, there was one more death due to IHD than expected (8 vs 7). When examined over time, there were more IHD deaths than expected among men less than 65 in the recent period leading up to the request (1984-1992); prior to 1984, there was a deficit of IHD deaths (SMR 48).

In conclusion, we observed a modest increase in deaths due to lung cancer, which is based on very small numbers (and therefore is not "statistically significant"), and may be due to chance. Two more lung cancers were observed than expected. The increase in lung cancer deaths occurred 20 or more years after starting; this finding is consistent with some of the previous studies suggesting an association with diesel fumes but the numbers are too small to permit a definitive conclusion.

The main concern at the outset of this investigation was that workers were dying young and that there were too many heart attack victims. We have found that, in fact, the experience of the workforce was similar to the Ontario average, and that fewer deaths from circulatory diseases were observed in this group than expected. This is consistent with the lack of an acute effect of CO on circulatory and heart disease among active workers. The Diesel/ MESC workers did indeed experience a "cluster" of heart disease deaths in the recent years leading up to the request, among those less than 65. This was not present in the previous time periods despite environmental conditions having been, no doubt, worse during the 1960s through early 1980s. Because conditions have been better in recent years, this cluster most likely represents a chance fluctuation. Given the absence of increased risk in the past and the improved conditions in the shops now, we do not believe there is cause for concern among current employees.

1.0 INTRODUCTION

In December 1992, the Health and Safety Studies Unit (HSSU) of the Ministry of Labour (MOL) received a request for a formal investigation of the health experience among United Steelworkers of America (USWA) members employed by Stelco Steel (Hilton Works) in the Mobile Equipment Service Centre and/or Diesel Shop. This request was prompted in part by the results of a recently completed preliminary investigation by the USWA (Local 1005) with the assistance of staff from the Occupational Health Clinic for Ontario Workers Inc (Hamilton Clinic). Concerns had been expressed about heart disease in particular; lung cancer was also mentioned. The request to MOL was signed by representatives from the Clinic, the Local, and the company, and a steering committee with representatives from the three groups was formed at the time. This report describes the investigation resulting from the request.

2.0 BACKGROUND (The findings of the preliminary investigation)

In the spring of 1991, the Clinic was contacted by health and safety representatives of USWA, Local 1005, regarding concerns they had about the Mobile Equipment Service Centre (MESC). Based on their observations, it appeared that many co-workers were dying earlier than expected, *many before reaching retirement age.* Concerns were also raised about the Diesel Shop. Exposures of concern included carbon monoxide and diesel fumes. In response, a preliminary investigation had been conducted by Clinic staff with assistance from Jim Illot (USWA Local 1005 Health and Safety Representative, MESC) who collected the information on which the study was based. This represented many dedicated hours of searching for and obtaining the data. The history of the Diesel Shop and MESC is given in the preliminary report. In brief (as presented in the preliminary report), in 1953 the Diesel Shop was formed with 7 mechanics and a gangleader taken out of other departments; they maintained locomotives, derricks, trucks, etc. From 1954 through 1970, the number of mechanics increased. About 1970/71, a new building was built, called the MESC, and two-thirds of the workers in the Diesel Shop were moved to this facility. By the late 1970s, the total number of workers in the combined shops peaked at about 100-110 workers. In late 1992, there were about 75 workers.

The hypothesis investigated in the preliminary study was "whether the exposures within the MESC could be associated with elevated mortality rates for certain heart diseases, elevated rates for myocardial infarction, and elevated mortality rates due to cancer, and/or lung cancer". The report of this preliminary investigation was completed in September 1992 and updated December 1992.

In the preliminary investigation, the investigators attempted to form a cohort (study group) of all workers who had worked in the Diesel shop and/ or MESC for more than 5 years. As indicated in their report, the data were collected by a single individual from old seniority sheets, second-hand information from fellow workers and directly from surviving individuals or their surviving relatives. The cohort included a total of 137 workers. The collector of the data gathered age, start and finish dates, age at significant outcomes, and "name of outcome". The observed deaths were compared to that expected in the general population of Ontario. The risk was estimated as the Standardized Mortality Ratio (SMR) which is the observed number of deaths divided by the expected, multiplied by 100 (the interpretation of the SMR is explained further below). The findings of the preliminary investigation were as follows: The observed and expected number (and SMR): for all causes 23 observed, 20 expected (SMR 115); heart disease 8 observed, 6 expected (SMR 133); acute infarction (heart attack) 8 observed, 3.6 expected (SMR 224); all cancer 10 observed, 5.4 expected (SMR 186); and lung cancer 4 observed, 1.8 expected (SMR 220). It was also estimated that there were a large number of nonfatal heart attacks.

3.0 EXPOSURES AND POSSIBLE OUTCOMES OF CONCERN

Exposure data

The Industrial Hygiene Department of Stelco has carried out assessments in these work areas. In 1986, an industrial hygiene evaluation of diesel exhaust fumes in the Diesel Shop, indicated that long-term tests for carbon monoxide (CO) ranged from 0 to 22 parts per million (ppm) compared to the Time-Weighted Average (TWA) exposure limit of 35 ppm. In December 1986, the results of continuous CO tests in the Tractor Garage ranged from 0 to a peak of 127 ppm.

The 15 minute average during the time of the peak value was 53.5 ppm which was less than the Short Term Exposure Limit of 400 ppm set by the MOL. The results of continuous CO tests in the MESC ranged from 0 to 128 ppm, with 15 minute average concentration during the peak of 41 ppm (compared to exposure limit of 400 ppm). In both shops the periods of higher levels of CO were directly related to times when equipment was started up inside the shop either to be moved or tested without the use of exhaust extractors. The Department recommended at that time that exhaust extraction devices available in the MESC and Tractor Garage must be used to keep diesel emissions in the shops at the lowest possible levels.

In June 1991, a report on another investigation of exhaust fumes in the MESC was completed. Full shift monitoring for CO revealed TWA concentrations of 5 to 23 ppm, and short term exposure levels of 8.8 to 143 ppm (compared to limit of 400 ppm). Personal CO monitoring in the MESC ranged from 2 to 10 ppm. A number of recommendations were made at that time. A follow-up report in December 1991 on the "fast lane" area of the MESC demonstrated 8-hr TWA CO concentrations of 0.1 to 3.8 ppm.

Carbon monoxide and heart disease

Heart disease, which includes hardening of the arteries and heart attacks (also known as ischemic heart disease), is the most frequent cause of death in North America, accounting for about one-third of deaths. Heart disease is caused by many things, with the major risk factors being increased blood pressure, cigarette smoking, and elevated cholesterol. Carbon monoxide (CO) may be hazardous to individuals with preexisting heart disease (Atkins and Baker, 1985). CO reduces oxygen delivery to the heart muscle. Thus, in workers with coronary artery disease (and compromised blood and oxygen delivery to heart cells), CO can precipitate symptoms such as angina or even a heart attack. This would be expected to have a relatively rapid onset, i.e. within minutes to hours of exposure. There are also suggestive findings from animal and laboratory studies that CO exposure accelerates atherosclerosis but this is less clear. Possible mechanisms include increasing platelet stickiness, changing the metabolism of fat and cholesterol, or increasing vessel leakiness to cholesterol (Stern et al, 1988).

Case reports of exacerbation of coronary artery disease by (acute) occupational exposure to carbon monoxide leading to fatalities have been reported (Atkins and Baker, 1985). The effects of chronic occupational exposure to CO are not as clear. Edling et al (1987) examined a cohort of bus garage employees to determine whether there might be an increased risk of cardiovascular disease associated with diesel exhaust exposure. The results showed no significant differences between observed and expected number of deaths from cardiovascular disease, although the authors noted that the "so-called healthy worker effect was relatively weak for cardiovascular disease" with a risk ratio compared to national rates of 0.9 (equivalent to a Standardized Mortality Ratio or SMR of 90).

Stern et al (1988) investigated the effect of occupational exposure to carbon monoxide on heart disease in a retrospective study of New York City bridge officers (who had low CO exposure) and tunnel officers (high CO exposure). Investigation of environmental conditions over time demonstrated that 24-hr average CO levels inside the tunnels were 53 ppm in 1961, 35-40 ppm in 1968, and 63 ppm in 1970. In that year, fresh-air ventilation systems were installed in toll booths. In 1981, daily sampling over two weeks by direct-reading instruments found mean area levels of CO inside the tunnels of 38.3 ppm, 23.0 ppm outside the bridge toll booths, and personal samples of 10.8 ppm collected on tunnel officers and 6.2 collected on bridge officers. Compared to the New York City population, there were increased deaths from atherosclerotic heart disease (ASHD) among tunnel officers (SMR 135, 90% confidence interval 1.09-1.68) but not in bridge officers (SMR 85). The risk in tunnel workers was elevated at younger ages (SMR 174 for ages 50-59) but not for those 60+ (SMR 100). Using a statistical model, the authors compared the risk of mortality from ASHD among tunnel officers with that of the less-exposed bridge officers. The elevated risk declined after cessation of exposure, with much of the risk dissipating within as little as five years.

Diesel exhaust and lung cancer

A number of studies and articles have suggested an association between exposure to diesel exhaust and lung cancer. The International Agency for Research on Cancer (1989) examined this and concluded that diesel exhaust is probably carcinogenic to humans but that the

epidemiologic evidence is limited.

4.0 METHODS (What did we do?)

On February 1, 1993, investigators from HSSU met with the steering committee and other representatives from the Clinic, Local 1005, and Stelco to discuss the preliminary investigation; to walk through the worksites; and to discuss the feasibility of undertaking an investigation in response to the request. Possible reasons for difficulty in the interpretation of the preliminary findings were also discussed at the meeting, and included whether all relevant workers had been included in the cohort; and the documentation of causes of death (i.e. whether the causes had been objectively confirmed and based on death certificates as they are in the general population of Ontario).

The MOL agreed to obtain the study list from the Clinic; obtain the missing dates of birth from the company; obtain the cause of death information from the Registrar General or Statistics Canada; and re-run the mortality analysis based on the 5-year eligibility criterion as had been used in the preliminary analysis. We have subsequently transmitted progress updates on March 5 and April 29, 1993.

Compilation of the cohort list: In addition to the lists forwarded to us from the Clinic, the company undertook to explore their records to determine a) if there were any deaths (observed events) among diesel/ MESC workers that were not yet included but should be; and b) whether there were additional former diesel/ MESC workers not known to have died but who should be included in the cohort.

Determining cause of death: Vital status (i.e. occurrence of deaths) was ascertained up to the end of 1992. For most deaths from 1980 on, we obtained the underlying cause of death from the Registrar General. For deaths prior to 1980, we wrote to Statistics Canada, and obtained the underlying cause of death. The causes for three deaths were not available from these sources: for these deaths (two died in Europe), the medical information as to cause of death

available in the personnel file or from family members was used (one was heart disease, two were cancer).

Analysis: The mortality experience of the Diesel/ MESC cohort was compared to that expected in the general population of Ontario, after adjusting for age, calendar period and gender (all were males). The technical details are given in the Appendix. Briefly, the risk is estimated as the standardized mortality ratio (SMR) defined as the Observed (number of deaths) divided by the Expected (number of deaths) multiplied by 100.

The observed number is that obtained from the cause of death information. The number of expected deaths was calculated using the computer program ("MANYRS") by Coleman et al (1986). We stopped following individuals when they reached age 85 as recommended by the program documentation (see Appendix).

Interpreting the SMRs:

If the SMR = 100, then the group experience for the Diesel Shop/ MESC workers is the same as the Ontario average.

If the SMR is greater than 100, then more events have been observed in the Shop workers than would be expected in the general population.

If the SMR is less than 100, then fewer events have been observed in this group than that expected in the general population of Ontario.

Because of random fluctuation with small numbers of events, small deviations less than or greater than 100 (e.g. an SMR of 90 or 115) may be due to chance.

Healthy Worker Effect: Working populations have been generally observed to have somewhat better health and consequently overall mortality somewhat below that of the general population. This has been referred to as the "healthy worker effect". This is usually most marked in the first years after starting work, and is usually stronger for circulatory disease than for other conditions, such as cancer.

5.0 RESULTS (What did we find?)

The cohort: Dr. Cheung provided the names of a number of additional workers eligible to be included as well as additional deaths. The final names were forwarded from the company on June 5, 1993. A total of 160 workers who worked in the Diesel Shop/ MESC for greater than 5 years were identified and entered in the computer database. Subsequently in August, union and management agreed to delete 3 individuals from and add 10 others to the list; this information was transmitted on September 14, 1993, yielding a total of 167 workers.

Findings: As of December 31, 1992, 31 workers were known to have died; one of the deaths occurred after age 85. Mortality for selected causes is presented in Table 1. The number of deaths from all causes was the same as that expected. The number of deaths from cancers was about 60% higher than expected. The results for those types of cancer for which more than 1 death occurred are displayed. Deaths from lung cancer were also increased; 4 of the 5 lung cancer deaths (compared with 1.95 expected) occurred 20 or more years after first employment in Diesel/ MESC (Table 2); only about one was expected prior to this point. Three of the five lung cancer deaths occurred in the recent time period, 1984-1992 (Table 3). Two lymphatic and hematopoietic cancers were observed; they were of different types (one was chronic lymphatic leukemia; the other lymphoma).

Circulatory disease includes mainly heart disease and stroke. There were fewer deaths due to circulatory disease than expected (SMR 91). Ischemic heart disease (IHD) is the subtype of circulatory disease which includes coronary artery disease and heart attacks. All 12 circulatory deaths were due to IHD. The SMR for IHD was slightly above that expected (121); there was no pattern according to years since first in Diesel/ MESC (Table 2). There were no deaths due to stroke, the other main part of circulatory diseases (1.4 were expected). Mortality for non-malignant digestive diseases was doubled, due to increased deaths from cirrhosis (Table 1).

Additional analyses suggested that mortality among those dying at age less than 65 was less than expected for all causes, and for circulatory disease, and was only slightly higher than that

expected for IHD (8 vs 6.8; Table 3). We then examined the occurrence of these events over time; among those less than 65, there were more IHD deaths than expected limited to the recent time period leading up to the request (1984-1992) (Table 3). Prior to 1984, there was, in fact, a deficit of IHD deaths (SMR 48) (that is, there were fewer observed deaths than expected).

6.0 DISCUSSION

In this study, we found that fewer Diesel Shop/ MESC workers died of circulatory disease than expected, while deaths from heart disease were about the same as expected. In particular, with respect to the concern raised in the Background of the Preliminary Investigation that "co-workers dying earlier than expected, before reaching retirement age", the results of this study indicate that among those dying at age less than 65, there were fewer deaths observed than expected from circulatory disease (92% of the Ontario average) and only slightly above that expected for IHD (SMR 118). This is not consistent with an acute effect of CO on circulatory and heart disease that one might expect among active workers. The workers were correct in observing a "cluster" of heart disease deaths in the years leading up to their request, among those less than 65 (i.e. in the time period 1984-1992). This was not present in the previous time periods despite environmental conditions having been, no doubt, worse during the 1960s through early 1980s. Because conditions have been better in recent years, this cluster most likely represents a chance fluctuation.

The pattern that we observed (with essentially no increase in IHD deaths in the Diesel Shop/ MESC workers less than age 65 age) contrasts with that reported by Stern et al (1988) who found a marked increase (SMR 174) among those age 50-59. Our finding of no healthy worker effect with respect to IHD is similar to that found by Edling et al (1987) for circulatory diseases. The general population is not an ideal comparison group for studies of working groups, but the rates based on the general population are readily available and because they are based on large numbers, are very stable or precise. It is not known how our results would differ if a working group not exposed to CO (e.g. another department at Stelco) were used for comparison instead

of the general population.

The exposure data available indicate that the CO concentrations in the Diesel Shop and MESC were well below the TWA exposure levels; in fact, the upper range of the 8-hr TWA concentrations at Stelco (about 22-23 ppm) were considerably lower than, for example, the 24-hour concentrations recorded in the New York City tunnels (38-63 ppm)!

The increase in deaths from lung cancer is modest (SMR 179), is based on very small numbers (and therefore is not "statistically significant"), and may be due to chance. Two more lung cancers were observed than expected. The increase in lung cancer deaths was observed 20 or more years after starting; this finding is consistent with some of the previous studies suggesting an association with diesel fumes but the numbers are too small to permit a definitive conclusion.

As with all investigations, this study has limitations. The absence of a working group for comparison has been discussed. In addition, the small size of the group limits the power or statistical ability to detect true increased risks if, in fact, they exist. However, the more complete ascertainment of the cohort, and the use of cause of death information from the same source used for comparison are advantages of our investigation.

CONCLUSION

The main concern at the outset of this investigation was that workers were dying young and that there were too many heart attack victims. We have found that, in fact, the experience of the workforce was similar to the Ontario average for IHD, and that fewer deaths from all circulatory diseases were observed in this group than expected. We cannot rule out the possibility that there was a small effect of employment on mortality risk, but we can state that there was no substantial effect of employment on heart attack or lung cancer risk. We did not observe a strong healthy worker effect due to IHD. As we have indicated, the general population is not the best comparison group, but in light of these findings we do not recommend selecting another group of Stelco workers for comparison. The main reason is that, given the size of the MESC/

Diesel group available for study, there would not be sufficient statistical ability or power to detect a meaningful or conclusive difference. Given the absence of increased risk in the past and the improved conditions in the shops now, we do not believe that there is cause for concern among current employees.

ACKNOWLEDGEMENTS

We are grateful for the assistance and cooperation of the Steering Group (John Oudyk, Jean Paul Marin, and Dr. L. Cheung). Mr. Jim Illot was instrumental in starting the assembling of the cohort, and in obtaining much of the data. Ms. Irene Rule entered the data into the computer.

REFERENCES

Atkins EH, Baker EL. Exacerbation of coronary artery disease by occupational carbon monoxide exposure: a report of two fatalities and a review of the literature. Am J Ind Med 1985;7:73-79.

Coleman M, Douglas A, Herman C, Peto J. Cohort study analysis with a Fortran computer program. Int J Epidemiol 1986;15:134-137.

Edling C, Anjou C-G, Axelson O, Kling H. Mortality among personnel exposed to diesel exhaust. Int Arch Occup Environ Health 1987;59:559-565.

International Agency for Research on Cancer. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Vol 46. Diesel and Gasoline Engine Exhausts. 1989;132-141, 148-154.

Stern FB, Halperin WE, Hornung RW, Ringenburg VL, McCammon CS. Heart disease mortality among bridge and tunnel officers exposed to carbon monoxide. Am J Epidemiol 1988;128:1276-1288.

APPENDIX Details of the Analysis

The number of expected deaths were derived by multiplying the sex-, age-, calendar year-, cause-specific Ontario mortality rates (in 5-year age and calendar-time groups) by the number of person-years at risk (PYAR) of dying. The accumulation of observed deaths and of PYAR began with the date starting in the Diesel/ MESC shops according to the dates from the Clinic/ Local union and Company lists or January 1, 1950, whichever came later (because Ontario death rates are available since 1950 only). Observation ceased on December 31, 1992 or the date of death whichever occurred earlier. Persons not known to be deceased were assumed to be alive at the study end date.

The risk is estimated as the standardized mortality ratio (SMR) defined as [observed/ expected x 100].

TABLE 1
Mortality from Selected Causes, Diesel Shop and MESC,
Compared to the General Population of Ontario
To the End of 1992, Stelco, Hamilton, Ontario

Cause of death	OBS	EXP	SMR
All causes	30	30.23	99
All malignancies	13	8.07	161
Digestive cancer	3	2.38	126
Lung cancer	5	2.80	179
Lymphatic & Hematopoietic	2	0.74	269
Circulatory Disease	12	13.15	91
Ischemic Heart Disease	12	9.93	121
Gastrointestinal disease	3	1.53	196
Cirrhosis	2	0.89	226

TABLE 2
Mortality from Lung Cancer and Ischemic Heart Disease
According to Years since in Department
Diesel Shop and MESC, Stelco, Hamilton, Ontario

Years Since Starting in Department	Lung Cancer		IHD	
	OBS/EXP	SMR	OBS/EXP	SMR
0-4	0/ 0.06	0	0/ 0.47	0
5-9	1/ 0.14	719	1/ 0.79	127
10-19	0/ 0.65	0	3/ 2.63	114
20-29	2/ 1.11	181	6/ 3.44	175
≥ 30	2/ 0.84	239	2/ 2.64	76
Total	5/ 2.80	179	12/9.93	121

TABLE 3
Mortality from Selected Causes
According to Age at Death and Calendar Period
Diesel Shop and MESC, Stelco
Hamilton, Ontario

Cause of Death	Age at death			Calendar Period			
				Up to 1984		1984-1992	
		OBS/EXP	SMR	OBS/EXP	SMR	OBS/EXP	SMR
All causes	≤ 65	20/21.2	94				
	> 65	10/ 9.0	111				
All malignancies	≤ 65	9/ 5.5	163				
	> 65	4/ 2.6	157				
Lung cancer	≤ 65	2/ 1.9	105	2/ 0.9	222	0/ 1.0	0
	> 65	3/ 0.9	337	0/ 0.2	0	3/ 0.7	435
Circulatory disease	≤ 65	8/ 8.7	92				
	> 65	4/ 4.4	91				
IHD	≤ 65	8/ 6.8	118	2/ 4.2	48	6/ 2.6	229
	> 65	4/ 3.1	127